REPORT

(dated 10th September 2002)

Panelist Name: Christina Lockyer

For Consideration by the Indirect Effects Expert Panel

Please answer the following question, supporting your opinion as extensively as possible.

For each stock, is the estimated number of dolphins affected by the tuna fishery, considering data on sets per year, mortality attributable to the fishery, indicators of stress in blood, skin and other tissues, cow-calf separation, and other relevant indirect effects information, at a magnitude and degree that would risk recovery or appreciably delay recovery to its OSP level (how and to what degree)?

Background

The boundary limits of the species' populations appear not to have changed much over time apparently so that the species' distribution within the ETP region has remained stable. Surveys undertaken in recent years (1998 on) have included an enlarged range compared to earlier surveys (pre-1992). However, there have been no surveys and abundance / population estimates – except model predictions - between 1992 and 1998. This would appear to have been a critical period in the tuna fishery when new fishing regulations came into force. The abundance has appeared stable over time since mid-1970s, with a suggested increase around 1990 (Gerrodette & Forcada 2002). However there are no trends in abundance over 26 years, 1974 – 2000. For northeastern offshore spotted dolphins (spotters) – low-high is 494 –954 x 10^6; for eastern spinner dolphins (spinners) – low-high is 271-742 x 10^6; coastal spotted dolphins (spotters) – low-high is 97-228 x 10^6 but for this species the abundance only relates to 1998-2000. The problem is that there is no baseline for coastal spotters which represent several stocks, all requiring separate management.

Northeastern spotters are at ca 20% and spinners at ca 35% pre-exploitation levels. The possibility of continuation at low level is likely if there is instability, and even if there is stability but no growth. Even small changes in environmental conditions or intrinsic population changes could make the population decline further and certainly not recover. This assumes the 60% population at carrying capacity represents the maximum net productivity. There are several references in papers to a likely population increase (offshore spotters and eastern spinners) up to 1990 and then a decline (Wade 2002; Gerodette & Forcada 2002). At about this time fishery regulations changed affecting setting and kill rate. In the light of this, one might argue that any increase should have continued on after 1990; but apparently it has not. This suggests that the actual chasing and fishery practice are hindering recovery if one cab be assured that the ecosystem has remained stable and that carrying capacity has not altered.

The obvious observable mortality is clearly less than critical now as whole schools captured generally escape alive; however, even a very low mortality rate in a few susceptible individuals will be significant if population growth is unstable because birth rates have fallen or neonate mortality is high. If additional mortality occurs following the seining procedures but is not observed, population recovery would seem not possible.

There are several studies that present information on stress levels assessed from physiology and histopathology (Cowan & Curry 2002; Romano et al. 2002), behavioural studies and also demographic parameter changes. Clearly stress is an important issue and especially with

respect to specific segments of the populations such as calves or other susceptible individuals.

The present outlook therefore appears unpromising, and now is a critical time to assess what may be going wrong, as presently there is no assured foreseeable recovery to OSP for offshore spotters, eastern spinners nor coastal spotters..

Discussion

Fishery sets per year

The fishery regulations have changed in a little over a decade, resulting in fewer lethal sets on dolphins with better opportunities for dolphin escape during "back-down". This has also resulted in a sharp decrease in direct observable dolphin mortality, and there is an associated loss of biological samples for studying demographic parameters (age, reproduction, etc. directly from carcases). However, dolphins are still chased because of their association with tuna, and whilst they may avoid capture in the seine net, they are still exposed to potential physiological stress from the chase. The problem would therefore appear to be not one of direct take and mortality but to be uncertainty where it is difficult to observe and even estimate death and lethal injury from delayed shock – so-called "capture myopathy" or loss of animals such as calves because of abandonment during long chases or exhaustion and subsequent predation, etc.

Northeastern spotted dolphins (spotters) are chased twice as much as eastern spinner dolphins (spinners) – x10.6 annually compared to x5.6, and captured nearly five times as often – x3.2 annually compared to x0.7 (Archer et al. 2002; SWFSC 2002). Coastal spotters are chased and set upon only x2 annually and caught only x0.3 annually (SWFSC 2002). These calculations are the most recent, and I accept them rather than the estimates presented by Scott (2002) which were based on earlier data. Scott argues for much lower rates of capture based on his own calculations. The chasing and setting likely has a conditioning effect or type of habituation on spotters as it is almost once a month (SWFSC 2002) and evidence is that northeastern offshore spotters and eastern spinners demonstrate high evasive indices in response to chasing and capture (Mesnick et al. 2002). There is also some pre-knowledge of the fishery routine when in the net as dolphins appear to anticipate "back-down". Coastal spotters are only chased twice a year and have negligible capture rate. However, it would seem that there is scope for much school disruption during chasing – socially, feeding and reproduction. The problem with assessing the impact on the coastal spotters is that recent genetic evidence (Escorza-Trevino et al. 2002) indicates at least six potential small populations rather than one, all requiring separate management. The history of exploitation on these populations is therefore difficult if not impossible to fathom, as they may even have suffered the worst declines many years earlier (but I do not know, and probably neither does anyone else for certain now). Despite the much lower chasing and setting upon rate compared to the other two species, their future and recovery is difficult to predict as one cannot say if they are stable, increasing or decreasing.

One additional piece of information came to light during panel discussion in that there is some level of unregulated fishing taking place by small yellowfin tuna boats that do not carry observers (information at the 4-6 September La Jolla meeting supplied by Nicole LeBoeuf). Anecdotal reports suggest that there may be incidental kill during setting in this sector of the fleet. In addition it was also noted that the use of

a type of explosive fire cracker was used during seining in a few instances by some part of the fleet, but actual hard data on frequency of use is lacking. Therefore, without firm knowledge about what is happening regarding these two factors, one cannot be certain about statements on kill of dolphins or their recovery.

Mortality attributable to the fishery

One of the problems is that there are no surveys and abundance estimates in the critical period between 1992 and 1998 (Gerrodette & Forcada 2002). There was a suggestion of an increase around 1990, but overall the abundance has remained stable – neither growing nor declining since the late 1970s.

Age distributions for northeastern spotters have remained stable over time. Despite a lack of actual age data in the 1997-2000 period, what look to be reliable age distributions derived from colour patterns provide similar distributions as earlier years. The situation in eastern spinners is not so reassuring in that actual age data from pre-1994 appears to present an unstable distribution (Chivers 2002). There are too few data to derive current age distributions, and spinners do not have age-related colour pattern changes, so one does not know what may be happening. It is of great concern that the age distributions in northeastern offshore spotters indicate a much lower frequency of calves and 0-1 yr old animals as well as 4-8 yr animals (Archer & Chivers 2002). However, it should be said that in part some 0-1 yr animals are under-represented because of non collection of teeth.

Indicators of stress in blood, skin and other tissues

Temperature rises from the moment of chasing with heat being dissipated via the dorsal fin skin and other appendages. Evidence (apart from a single female in a sample of 48 dolphins) indicates that core temperatures do not rise so that internal organ damage and foetal damage is unlikely (Pabst et al. 2002). Nevertheless, even one such animal may be significant in this situation if irreversible damage occurs resulting in death later on or in increased susceptibility to disease or subsequent stress. In a situation where population growth is borderline, mortality of just a few animals – the outliers of the norm, can tip the balance.

No clear evidence of effects of repeated chase and encirclement on the immune system of offshore spotters was demonstrated (Romano et al. 2002). However, changes in T cell counts suggested a likely deterioration of the immune system after recapture and several sets, eventually leading to susceptibility to disease perhaps. Evidence of tissue analyses indicates that despite intense stress reactions to chasing / setting, the physiological situation appears reversible and is not generally suggestive of frequent lethal capture myopathy – except in a few susceptible individuals (Forney et al. 2002). While capture stress may not generally be a significant problem, there is always the possibility for sets to "go wrong" where dolphins may become entrapped in an unfavourable part of the net where drowning / suffocation or cardiac arrest may ensue. However, disregarding this possibility, even death of a few (one or two per net set or chase) may constitute unacceptable additional mortality in a population experiencing other mortality factors e.g. calf loss.

A study described and tested by Southern *et al*. (2002) utilises a new promising technique for detecting stress levels in animals from skin protein profiling. This is a neat and interesting technique with great potential – not just for the results presented so far but for the fact that

tissue can be used retrospectively from archival tissue banks and also acquired remotely by biopsy from currently living animals at sea. Dizon et al (2002) demonstrated that the technique could indicate stress experienced during the fishery operation, but that there were some concerns over sampling. This should definitely be a study to be explored further. One concern is the possible need to standardize skin collection site on the body. A study to investigate such should be feasible to set up and undertake in the future.

St Aubin (2002 – two papers) presented information on stress from blood chemistry and other physiological means. Whether or not actual stress symptoms observed are derived from the fishery activities or other causes is unknown, and in any case they were not assessed as fatal. Even first capture animals were not truly unstressed, and these form the "baseline" data. One interesting point is that stress hormone levels increased even while the animals were relatively calm in the net! It is clear that even if animals become conditioned / habituated to chasing and capture, and learn the fishery routine (Santurtún & Galindo 2002), they may still be highly stressed because they dislike the situation even if they are not totally fearful.

On the stress topic, I accept much of Scott's (2002) criticism of the inadmissibility of the physiological effects of stress, because there is little hard evidence. However, this does not mean that it cannot happen, and there are indications that it can in some instances. The biggest problem is obtaining reliable baseline data for blood chemistry, hormone levels and pathology in these species that are subjected to the fishery practices. A big concern is that throughout all the stress-related investigations, it has therefore been almost impossible to relate results and findings to true baseline data. In many investigations, it would be valuable to attempt to find information relevant to the particular study on other similar species that are not exposed to fishery operations and handling.

Cow-calf separation

There has been a significant decline in eastern spinner calves between 1988-93 and 1998–2000 (Cramer & Perryman 2002). (The proportion of calves in schools is significantly less in 1998 and 2000, compared with 1988, 1992 and 1993, despite there being no trend.) There has also been a possible change in school structure (smaller proportion of juveniles) over time – fewer juveniles in 1987 compared to 2000, but no significant downward trend was observed. Fewer calves definitely go hand in hand with a consequence of fewer juveniles. This information underlines the apparent low apparent reproductive rate – a single significant factor in population growth and recovery. Whatever the cause, fewer calves are either a reflection of or result of low growth and associated no population recovery.

Calf "loss" could probably be the single most important factor in low growth and non-recovery and could explain the few calves found. Neonate calves may expend x4 – x5 energy of an adult to keep up with the school during a chase (Edwards, 2002). This means that >30 min chase may exhaust the calf so that it is left behind. In this state, it will be vulnerable to predator attack and may starve, depending on age and feeding ability. Neonate calves also have lower myoglobin values in muscle than adults leading to faster exhaustion. During a chase – especially a long one, suckling will be completely disrupted so that the calf cannot replenish energy reserves. The peak calving periods are in summer and winter although females can give birth year-round. The suggestion to avoid schools with calves may therefore be problematic, but maybe this chasing and setting-upon practice could be avoided during seasons of peak births when calves are very small, weak and vulnerable. Chasing of schools with small calves could be kept to 30 min. maximum.

Scott (2002) heavily criticizes the possible effect of calf loss on the ability of the dolphin populations (notably offshore spotters) to recover. Whilst he has estimated that the level of mortality – unobserved or observed and unobserved combined, to be extremely low in calves and at a level that should not impact the populations, the problem is because it is an age-specific mortality rather than one affecting all or random age groups. Specifically calf mortality has a similar effect to low reproductive rates, and must certainly adversely affect population growth (and hence recovery), even if it cannot be accurately measured. There is enough evidence to take a precautionary attitude to calf loss, and try to prevent it. Scott also questions the likelihood that mothers will not abandon their offspring because the bond is very strong. This is certainly true in mothers with new born and very young calves, but the bond may be diminished with time and especially when the calf is less reliant on the mother. However, there are examples in many species where the young may be abandoned if the mother's life is at risk or she is unable to provide milk because of unsatisfactory energy resources (e.g. seals, sea otters when there are twins, etc.).

Other relevant indirect effects information

Age structure and Reproduction

Importantly, Forney et al. (2002) state that there are significantly less pregnant and lactating females in recent years compared to pre-1992. Decrease in fecundity and calf-rearing would be a key factor in low / no population growth. The age structure information (Chivers, 2002; Archer and Chivers, 2002) indicates a lower than expected number of neonates and yearlings and also certain juvenile segments. The information tendered by Edwards (2002 – two papers) also predicts losses of neonates and small calves as a result of long chases and mother-calf separation, calf exhaustion and subsequent vulnerability to abandonment and predation, etc. All these independent sources of information point to one very likely cause of non-recovery of populations: that of a combination of possible lowered fecundity and low neonate survival.

Conclusions

The following represent the main concerns and recommendations. At present it is clear that there is no compelling evidence that either the offshore northeastern spotters or eastern spinners are recovering – even if their situation may presently appear stable; nor are they likely to recover given the variety of evidence of indirect effects which may be sufficient to prevent actual population growth. Thus recovery relative to OSP is a moot point. Regarding the coastal spotters, there is insufficient evidence to make any constructive statement. If the "population" truly represents at least six local stocks, each requiring separate management, then it will be difficult to relate present status to pre-exploitation levels.

- Physiological stress during chasing and setting upon does occur in dolphins but the effects are probably generally reversible or do not cause lethal damage.
- A very few individuals in the population will always be susceptible to stress and possibly capture myopathy. The loss of even a few such animals could represent risk to recovery of populations.
- Calf loss through prolonged chasing (>30 min.) is likely a significant problem. Neonates are most at risk, and all measures possible should be taken to try to avoid chasing and setting on schools that include very small animals. Calf loss = lowered recruitment, and will definitely affect recovery because overall population growth will remain low or non-existent. My own opinion is that this factor alone

MAY be the single most significant factor in non-recovery of the population. At the very least, the situation demands intense investigation.

- Evidence for lowered fecundity is also a big concern. This will have the same effect as calf loss.
- Additional anecdotal information on the continued undocumented setting upon and subsequent death of dolphins by a number (undetermined) of small tuna vessels confounds what predictions can be made using the documented evidence as presented. This needs to be investigated to determine the scale of the problem; indeed if it is a significant problem.
- There is also undocumented reporting of the continued use of fire crackers or small explosives in the nets (to disperse dolphins) which raises the same concerns as the above.

References

Archer, F. and S. J. Chivers. 2002. Age structure of the Northeastern spotted dolphin incidental kill by year for 1971 to 1990 and 1996 to 2000.

Archer, F., T. Gerrodette and A. Jackson. 2002. Preliminary estimates of the annual number of sets, number of dolphins chased, and number of dolphins captured by stock in the tuna purse-seine fishery in the eastern tropical Pacific, 1971-2000.

Chivers, S. J. 2002. Age structure of female eastern spinner dolphins (*Stenella longirostris orientalis*) incidentally killed in the eastern tropical Pacific tuna purse-seine fishery.

Chivers, S. J., and M. D. Scott. 2002. Tagging and tracking of *Stenella* spp. during the 2001 Chase Encirclement Stress Studies Cruise.

Cowan. D. F., and B. E. Curry. 2002. Histopathological assessment of dolphins necropsied onboard vessels in the eastern tropical Pacific tuna fishery.
Cramer, K., and W. L. Perryman. 2002. Estimation of reproductive and demographic parameters of the eastern spinner dolphin (*Stenella longirostris orientalis*) using aerial photography.

Dizon, A., A. Allen, N. Kellar, and Sárka Southern. 2002. Stress in spotted dolphins (*Stenella attenuata*) associated with purse-seine tuna fishing in the eastern tropical Pacific.

Edwards, E. F. 2002. Behavioral contributions to separation and subsequent mortality of dolphin calves chased by tuna purse-seiners in the eastern tropical Pacific Ocean.

Edwards, E. F. 2002. Energetics consequences of chase by tuna purse-seiners for spotted dolphins (*Stenella attenuata*) in the eastern tropical Pacific Ocean.

Escorza-Trevino, S., A. Lang and A. E. Dizon. 2002. Genetic differentiation and intraspecific structure of eastern tropical Pacific spotted dolphins, *Stenella attenuata*, revealved by mitochondrial and microsatellite DNA analyses.

Forney, K. A., D. J. St. Aubin, and S. J. Chivers. 2002. Chase Encirclement Stress Studies on dolphins involved in eastern tropical Pacific Ocean purse seine operations during 2001.

Gerrodette, T. and J. Forcada. 2002. Estimates of abundance of northeastern offshore spotted, coastal spotted, and eastern spinner dolphins in the eastern

tropical Pacific Ocean.

Mesnick, S. L., F. I. Archer, A. C. Allen, and A. E. Dizon. 2002. Evasive behavior of eastern tropical Pacific dolphins relative to effort by the tuna purse-seine fishery.

Pabst, D. A., W. A. McLellan, E. M. Meagher, A. J. Westgate. 2002. Measuring temperatures and heat flux from dolphins in the eastern tropical Pacific: Is thermal stress associated with chase and capture in the ETP-tuna purse seine fishery?

Romano, T., K. Abella, D. Cowan, and B. Curry. 2002. Investigation of the morphology and autonomic innervation of the lymphoid organs in the pantropical spotted, spinner, and common dolphins (*Stenella attenuata*, *Stenella longirostris* and *Delphinus delphis*) incidentally entangled and drowned in the tuna purse-seine fishery in the eastern tropical Pacific.

Romano, T., M. Keogh, and K. Danil. 2002. Investigation of the effects of repeated chase and encirclement on the immune system of spotted dolphins (*Stenella attenuata*) in the eastern tropical Pacific.

Santurtún, E., and F. Galindo. 2002. Coping behaviors of spotted dolphins during fishing sets.

Scott, M.D. 2002. Review of stress research on dolphin species encircled by tuna purse seiners in the Eastern pacific Ocean. (Paper submitted to the Secretary of Commerce under the International Dolphin Conservation Program Act.)

Southern, S., A. Allen, and N. Kellar. 2002. Molecular signature of physiological stress based on protein expression profiling of skin.

St Aubin, D. J. 2002. Further assessment of the potential for fishery-induced stress on dolphins in the eastern tropical Pacific.

St. Aubin, D. J. 2002. Hematological and serum chemical constituents in pantropical spotted dolphins (*Stenella attenuata*) following chase and encirclement.

SWFSC. 2002. Report of the overall IDCPA research program and results.

Wade, P. R. 2002. Assessment of the population dynamics of the northeastern offshore spotted and the eastern spinner dolphin populations through 2002.

Dated: 10th September 2002

Christina Lockyer